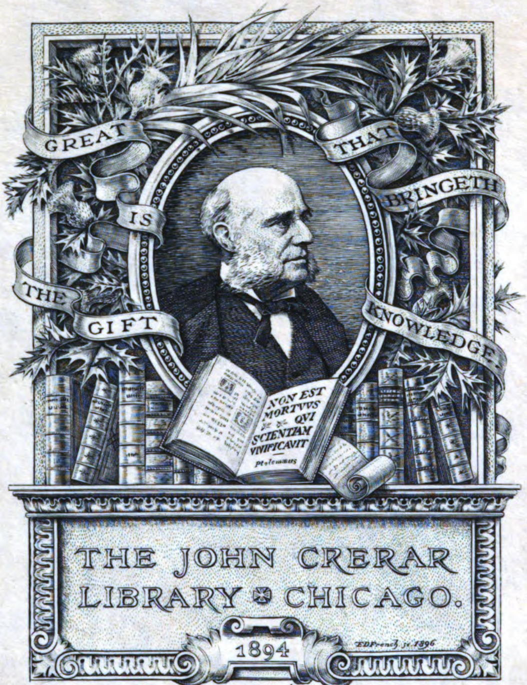
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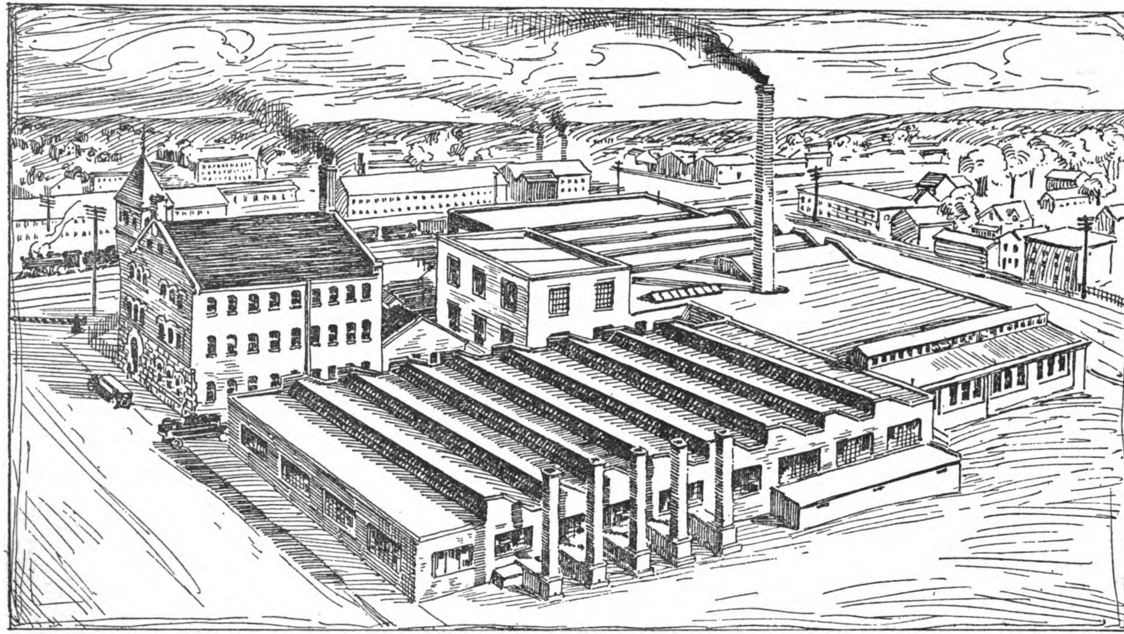


Plant of Clemson Bros., Inc., at Middletown, N. Y., Where Star Hack Saw Blades are Made

HACK SAW EFFICIENCY

A Practical Handbook of How to Test and Use Hand and Machine Hack Saw Blades

Issued by the manufacturers and distributors of Star Hack Saw Blades.

Manufactured by

CLEMSON BROS., Inc., Middletown, N. Y.

Sole Distributors

MILLERS FALLS CO., Millers Falls, Mass.

CLR

INTRODUCTION

HACK Sawing Efficiency is important to every machine shop owner and metal worker because it is so very necessary for them to know whether they are buying the most efficient blades and using them in the most efficient way.

Need for More Knowledge

To know this is important, not because each blade is a big cost item in itself—though it is surprising how fast poor blades run into real money—but because the work that hack saws do or fail to do in a shop of even moderate size involves thousands of dollars, in time of men and machines and profits won or profits lost.

For some reason the study of hack saw efficiency has received probably less thought and attention from engineers and investigators than any form of metal working as is shown by the almost total lack of books and magazine articles on the subject.

It may be this is because the low cost per blade has made the question seem relatively less important, or because the efficiency pioneers like Taylor and Gantt happened to devote their years of study and experiment to other kinds of metal cutting. The fact of course is that hack

sawing is very important—as important as any other metal working operation and the purpose of our $500 prize contest on "Testing Hack Saws" was to emphasize this importance and bring the latent interest on the subject to the surface. Following this we planned to publish a book such as this to put in available form standardized hack saw information that would have a permanent value. The contest was all we had hoped and more. We were almost swamped with replies which came from every corner of the world. Many were of real scientific value and they showed that more thought and study has been put on hack sawing efficiency by users and investigators than was generally realized by the American engineering and industrial world.

Results of Contest

Our contest has disclosed the fact, for instance, that in England a mammoth power machine has been developed that cuts work up to 26 inches square and a special English hack saw testing machine has been devised that is entirely automatic both in operating successive cuts and recording the time of the results.

Our original intention was to publish complete the papers of all the prize winners in our contest but we find that this would make a book of impossible size that will have much repetition and some confusing contradictions.

Hence it has seemed best to give a standard

outline of the best method to test and use hack saws based on our 30 years experience, adding notations of any special methods or novel ideas that the prize winners have evolved. Following this we have printed in full the paper which won first prize.

Prize Winners

The complete list of the prize winners was as follows:

1st Prize, \$250—J. C. Miller, Oak Park, Ill.
2d Prize, \$100—P. L. Wormeley, Washington, D. C.
3d Prize, \$50 —H. A. Dudgeon, Birmingham, England.
4th Prize, \$25 —Edward G. Herbert, Manchester, England.
5th Prize, \$15 —F. E. Merriam, Dayton, Ohio.
6th Prize, \$10 —C. B. Hamilton, Jr., Toronto, Can.
7th Prize, \$10 —Wm. R. Miller, Baltimore, Md.
8th Prize, \$10 —R. H. Porter, Durham, N. H.
9th Prize, \$10 —F. C. Schieber, Scranton, Pa.
10th Prize, \$10 —James Darrow, Lincoln, Neb.
11th Prize, \$10 —H. B. Milmine, Toledo, Ohio.

HOW TO TEST BLADES

YOU test hack saw blades of different makes because you want to be sure you are buying the kind that will make the most money possible for you in metal cutting.

It is a question that involves so much of your manufacturing expense in time and material that you naturally determine to find the facts with an accuracy that will leave no room for doubt.

Tests that Have Real Value

To get real facts you must cut the same kind of material during the entire test and have all the other conditions the same for one blade as for the others. Also you must test at least three blades to be sure you have an average instead of a single unusual performance which proves nothing.

Hand blades must be tested on a machine to get convincing proof of comparative quality. Otherwise you can never be sure that you are not using more pressure and a longer stroke at the beginning of the test than at the end when you have become fatigued. And of course, a comparison between the handsawing of two different workmen would have no value whatever as a test. In fact, hand sawing tests have little value unless they can be conducted in such a

way that accurate records can be kept of the results of many blades doing a large quantity of work, in which the law of averages will have a chance to offset the inaccuracies that are bound to occur in a shorter test.

A Severe Test Is Best

To make the machine test show a clear-cut comparison of relative blade efficiency in a short time the task should be a difficult one for a blade to accomplish. The combined conditions of speed, pressure and hardness of stock should be such as will ruin the average blade in about 5 to 15 cuts and not be a test under the conditions of actual work which might continue cutting for a long period. This more severe test has the vital advantage of showing the relative efficiency of the different blades in a far more emphatic way which might be compared to the accuracy of reading a micrometer as compared with the less exact caliper and steel rule.

Two Timing Methods

The time of each cut can be recorded from a stop watch or the number of strokes taken from an automatic counter attached to the machine. Knowing the speed of the machine, we can deduce from this stroke record the time of each cut. The counter has the advantage of being more accurate and of making it unnecessary to watch the machine so constantly.

The material most commonly used for a hacksaw test is round, unannealed tool steel

of about 2 inch diameter, but any stock can be used when the other conditions make it a severe test for the blades.

The cuts can be made to take off only about ⅛ inch of the steel so that the material cost will be small.

It is true that a test of this kind interferes with the regular work of one of your machines for the time being, but the temporary loss is of small moment as compared with the importance of being certain that you are using the best blades and using them in the way to get the most efficient results.

Conditions that must be uniform

In addition to having the material uniform, you must have uniformity of speed, length of stroke, pressure and tension of the blade. You must also make sure the blades are similar in gauge, in width and in number of teeth per inch.

The speed and length of stroke are made standard in most machines so that no effort to keep them uniform is necessary. If blades are the same length from hole to hole there will be no great care needed to maintain uniformity of tension. On this point Mr. J. C. Miller carries out an original idea of substituting a spring with tension gauge measured in pounds so he can be sure his blade tension is uniform in each case and know exactly what that pressure is. (See page 27.)

Equalizing Pressure

Equal pressure on blades of the same gauge and pitch gives a fair comparison. Mr. F. E. Merriam assumes that there will be times when it is necessary to make tests between blades of unequal gauge and pitch and has worked out a formula from which he figures the relative pressures that can be used to equalize this difference. (See note p. 23.)

For the purpose suggested, this is undoubtedly a formula of value, but it makes a blade test far more complicated and with the uniformity in blade dimensions which now prevails among manufacturers it should usually be possible to make a comparison between saws of exactly similar size.

Uniformity of material

Some testers use a method of rotation in cutting to offset the possibility of one blade cutting on a harder part of the test bar than another. The two most common are to change the blades after each cut and to cut the bar up into a certain number of pieces (12 for instance) and then make one cut on each piece in rotation. We are frank to say that we believe that this is another complication that only adds to the bother of making a test without appreciable benefit. For one thing, a variation in a steel bar is likely to come in spots so small that one cut would strike it without its affecting the cuts on either side.

It seems to us far better to make tests of more

blades and be surer of your average than carry the question of uniform conditions to an impractical extreme. Five blades or more are a much better test than three because they not only equalize variation but they prove far more conclusively which of the blades you are testing has the greatest uniformity.

Prove Uniformity

THE SIMPLEST TEST

To bring a test within a practical length of time, you can arbitrarily limit it to ten or fifteen cuts. In doing this, it is important to make the cutting conditions so severe that some or all of the blades will be ruined within that time.

To Shorten the Test

As already explained, the test can be made severe by increasing the feed pressure, by selecting material which is difficult to cut at the given speed or by increasing the speed of the machine (if this is practicable).

The test should not be so severe as to ruin the blades in less than about five cuts otherwise it usually means that the task set is so nearly impossible of performance that the results are freaky and misleading.

A severe test necessitates unusual care in easing the saw into the work for the first one or two strokes in each cut. Without this care it is a very easy matter to strip the sharp points off

the teeth on these first strokes and destroy a good part of the cutting life of the blade. If more care is used with one blade than another, of course, it makes the results worthless as a comparison. At least three blades of each make should be tested. More are an even better proof of uniformity.

The Necessity of Care

The relative cutting cost is the proper basis of comparison of blades and if the test has been a severe one there will usually be a decided difference in these costs even in a short test. If some or all the blades have failed to last out the full number of cuts, it is best to leave the unfinished cuts entirely out of the calculation in figuring the average cost per cut. Here is a specific test to illustrate:

TEST A.

Size of Blade	Machine Used	Pressure	Strokes per Min.	Stock Cut	Overhead and Labor Cost per Hour	Date
12x¾x.049"	"No name"	42 lbs.	126	1⅝ Annealed tool steel	20c	3/28/18

Name & No. Blade	No. of Cut and Time in Minutes of Each Cut 1	2	3	4	5	6	7	8	9	10	11	12	Total Time	Overhead & Labor Cost	Cost of Blade	Total Cost
A-1	2	2	2½	3	3½	4	4½	stopped	cutting				21½	.07	15	.22
A-2	2	3	3	3	3	3½	3	ran	off				20½	.07	15	.22
A-3	2	2	2½	2½	3	3½	4	4	4	4½	broke		32	.10⅔	15	.25⅔
B-1	2	3	4	4	4	4½	4½	4¾	5	5	5	5	50¾	.17	12	.29
B-2	2½	3	3½	4	4	4	4½	stopped	cutting				25½	.08½	12	.20⅓
B-3	2½	3	3½	4	4	4	4	4	4	4	4	4½	45½	.15	12	.27

A Blades—24 cuts for 69⅔c, or 2.9c per cut.
B Blades—31 cuts for 76⅓c, or 2.5c per cut.

Analyzing the above results we find that the "A" blades gave us 24 cuts at a total cutting cost of 69-2/3c, or 2.9c per cut, and the "B"

Analysis of Results

blades did 31 cuts for 76-1/3c, or 2.5c per cut. Making almost a half cent a cut advantage in favor of the "B" blade.

In those tests where all the blades are still cutting at the end of the test, a comparison can be made of the total cutting cost rather than the average cost per cut. Of course, the cost of blades should be included in this comparison.

This simplifies the calculation and shows up the difference in efficiency in stronger contrast than if the average is taken.

It must be remembered that any difference in the cost per cut becomes an item of constantly increasing importance when considered for a long period and on several machines.

A MORE SCIENTIFIC TEST

A More Conclusive Test

The test described will give you accurate comparative figures of the cost of cutting with each of the blades tested in the vast majority of cases. The most conclusive test, however, is to carry the cutting of each blade up to and just beyond its point of greatest cutting efficiency.

By this method the test is not ended arbitrarily at 10 or 15 cuts, but is continued to the point in each case where the efficiency of the blade begins to fall off—until it costs more in cutting

time to allow the blade to continue than it would cost to put in a new blade.

To illustrate the difference—it is possible that in a test arbitrarily limited to ten cuts A blade would show a lower cost per cut than B blade, but if the test were carried to an efficiency conclusion the A blade would refuse to cut after the twelfth cut and the B blade go on to the twentieth cut and win out in the end in having the lowest average cutting cost.

The Limit of Efficiency

In a test of this kind the cost per cut in labor and overhead is figured after each cut from the time or strokes recorded and the cost of each cut following the first is compared with the cost of the first cut. When this total increase in labor and overhead cost over the first cut equals or exceeds the cost of a new blade, the blade is discarded and the average cost per cut is calculated, including the cost of the blade.

To illustrate:

TEST B.

Saw No. A-1. Speed 120 strokes a minute. Labor and overhead cost, 24c per hr. No. strokes for 1c, 300. Cost of blade, 21c.

Test Showing Limit of Efficiency

Cut	Strokes	Cost per Cut		Total Increase in Cost
1	808	.027		—
2	1188	.039		.012
3	2535	.085		.070
4	3425	.114		.157
5	4520	.15		.280
	cost of labor	.415	A-1	.125
	cost of blade	.21	A-2	.131
		5) .6255	A-3	.119
	cost per cut	.125	A-4	.152
			A-5	.107
			5)	.634
	"A" make of blades average cost per cut			.126

Analysis of Results

The saw was run at a speed of 120 strokes a minute, or 7,200 strokes an hour. The labor and overhead charge was 24c an hour. From this we can figure the time cost in strokes at the rate of 300 strokes for 1c. The cost of the blade is 21c.

On the fourth cut the total increase in labor and overhead cost as compared with the cost on the first cut did not equal 21 cents, the cost of a new blade, so the test was continued for the fifth cut, which made the total increased cost 28 cents. This made the average cost per cut

for the five cuts 12.5 cents and the average for five tests of A blades 12.6 cents.

Use of Graphs

A common method of measuring test results is to reduce them to a graph based on time or number of strokes and quantity of material cut (see p. 36). As an additional exhibit of relative efficiency this graphic comparison has the advantage of being easily grasped, but if it is made the sole basis of comparison it fails to take into consideration the relative cost of the blades. Hence we believe that the comparative figures of the cost per cut have a much more definite and significant value where only one comparison is shown.

A "RUN OF WORK" TEST

Ordinarily tests should be made on exactly the same material, but it is possible to test saws while cutting material of varying sizes if this is known to be absolutely uniform in hardness and if the tester is willing to go to the trouble of measuring accurately the cross-section areas so as to make an exact comparison.

Thus:

TEST C.

"Run of Work" Test

Saw No. A-1. Speed 90 strokes a minute. Labor and overhead cost, 24c per hour. No. strokes for 1c, 225. Cost of blade, 16c. No. strokes equal in cost to blade, 3600.

Cut	Section	Area	Strokes Taken	Stroke Standard	Excess	Total Excess
1	1 x 1	1	425	425	——	——
2	2 x 2	4	1824	1700	124	124
3	2 x 2	4	1847	1700	149	271
4	3 x 1	3	1476	1275	201	472
5	3 x 1	3	1521	1275	246	718
6	2.5 x 3	7.5	3699	3187	512	1230
7	2.5 x 3	7.5	3948	3187	761	1991
8	2.5 x 3	7.5	4029	3187	842	2833
9	1 x 2	2	1665	850	815	3648
		39.5	225) 20434			

Cost of labor	.91
Cost of blade	.16
39.5)	1.07
Cutting cost per sq. in.	.027

A-1 cost per sq. in.	.027
A-2 " " " "	.031
A-3 " " " "	.023
A-4 " " " "	.042
A-5 " " " "	.041
5)	.164
Average cost per sq. in.	.032

Explanation of Method

This test should be carried to the efficiency limit the same as Test B. For the purpose of comparison each new blade is first timed on a standard steel bar of 1 inch cross area, and that number of strokes is taken as the standard by which the other cuts are compared for efficiency. It would be a tedious matter to calculate the cost of each cut as in Test B, so the calculation of efficiency loss is all made in strokes as compared with the number of strokes taken on the first cut.

In this case the first cut on the inch-square material was made in 425 strokes, which is taken as the standard from which the loss of efficiency in the subsequent strokes is figured.

Analysis of Results

The cost of the blade is 16c, which is equivalent in cost to 3,600 strokes. The area of each cross section is figured and the number of strokes taken for each cut is compared in each case with the number that would have been taken on a basis of equal efficiency to the strokes taken on the first cut. In the second cut, for instance, where the cross-section area was 4 inches, the stroke base was 4x425 or 1,700 strokes. As soon as the total excess strokes equal 3,600, the blade is replaced.

In figuring the cost per cut the calculation is reduced to a square inch basis for purposes of comparison.

Making a "run of work" test with hand blades is not feasible unless you are cutting some kind of uniform material where it is an easy matter to record the quantity cut by a large number of blades (such as a gross or half gross).

TESTS FOR EFFICIENCY

After the most economical blade has been selected, of course, it is equally important to make tests to determine how you shall use the

Tests for Speed and Pressure

blade to get the most efficient results. In machine sawing the two chief factors that determine this efficiency are the cutting speed and the feed pressure. Tests to determine the right speed and the right pressure should keep all the other factors uniform except the one under investigation and be reduced to the same final basis of lowest cost per cut.

TEST D.

Size of Blade	Machine Used	Blade	Strokes per Min.	Stock Cut	Overhead and Labor Cost per Hour	Date
12x¾x.049"	"No name"	"XY"	120	Soft Steel 2½" rd.	20c	3/28/18

Pressure	No. of Cut and Time in Minutes of Each Cut 1	2	3	4	5	6	7	8	Total Time	Overhead & Labor Cost	Cost of Blade	Total Cost
36 lb.	8½	8¾	9	9	13	14	14¾	15¼	92¼	.31	.16	.47
36 lb	10¾	11¼	12	12¼	12	11½	12	12¼	94	.31⅓	.16	.47⅓
36 lb.	9½	10	10½	10½	11	11¼	11½	11½	85¾	.29	.15	.44
42 lb.	9	9	9	9¼	9¼	9½	9½	9½	74½	.25	.15	.40
42 lb.	9	9	9	9	9½	9½	9½	10	81¼	.27	.15	.42
42 lb.	9¾	10	10	10	10	10	10½	11	74	.24⅔	.16	.40⅔

36 lb. $.138⅓.
42 lb. $.122⅔.

Pressure Tests

The same test blank can be used for this as for the blade test—the pressure instead of the blade being the factor under investigation. The test illustrated follows the same method as blade test A already described. A more exact pressure test could be made similar to blade test B.

Only tests of this kind can determine accurately under what pressure a given make of blade can work most efficiently, and it goes without saying that this is a factor which should be deter-

mined with accuracy and not guessed at or approximated.

If a saw blade can be run at a higher rate of speed and still keep the same cost per cut it is making you more money because it is increasing your output by just so much, and increased output gives you more goods on which you can make a profit. If faster cutting enables you to double your output, for instance, you are making a profit on twice the quantity of merchandise without any expense of increased factory facilities.

Limit of Speed Increase

However, you cannot afford to obtain this added speed at the expense of any material increase in the cost of your cut unless you have a large profit on the article—unless the sawing operation is a large part of your entire cost—and unless the other operations are speeded up to the same pace so that your greater output is an accomplished fact and not an increase that applies to this one operation alone.

GENERAL SUGGESTIONS

There are a few general considerations that should be borne in mind by every hack saw user. We have already spoken of the necessity of easing the first cut into the work. This is important—especially if the work has a corner that will catch the sharp new teeth.

It is better to use a machine that lifts the

General Suggestions

blade on the return stroke, for a dragging back stroke reduces the life and cutting value of your blades.

In hand sawing the same principle of lifting the blade on the back stroke holds good.

Appearance No Guide

Small reliance should be placed on judging blades by appearance. Mechanics have built up a number of traditions about judging hack saws by their looks that are almost entirely erroneous.

Some flaws like uneven set can be detected by examination of the blade, but whether a blade that looks good will make good or not is impossible for anyone to say.

Scleroscope Tests

Even scleroscope tests for hardness prove nothing, because they show only comparative degrees of hardness, and this alone is far from a final indication of relative hack-saw efficiency. The vital element of toughness or tensile strength which comes partly from the steel composition and partly from the tempering treatment cannot be measured by any scleroscope test.

We must rely on tests of actual use—the kind of tests we have here described—to show us the best make of hack-saw blades. When once we have found what make this is we can safely go out and buy blades by the brand and be confident that every blade we use is giving us the lowest cost per cut.

Note. "It is necessary to classify the blades as to thickness, pitch and manner of set, and such classification shows considerable differences. This having been done, the relative values of the blades can readily be determined. The speed of the saws being the same, the regulation, or adjustment, is a matter of varying the pressure or feed; and in order to secure this condition it is first necessary to adopt a standard pressure, which can best be specified in pounds per inch of tooth width, thus caring for the variation in tooth width and pitch. Twenty to thirty pounds has been found to be productive of the best results, since it does not overload the saws and is still sufficient to produce quick test results.

The feed pressure is the force necessary to produce a moment equal and opposite to the combined moment of the adjustable weights and the saw frame. This force has a moment arm equal to the distance between the center of the bar being cut and the point of frame suspension and for good test conditions should be at least 50 to 60 lb. A standard feed pressure per inch of tooth width should be adopted and as already mentioned, 20 to 30 lbs. will produce good results. From this unit pressure the total pressure on the saw can be worked out and the location of the adjustable weight determined from the equation of equilibrium of the forces in question. The following formulas give the location of the adjustable weight:

$$r = \frac{(T \times K) \quad - \quad (W \times R)}{w}$$

$$T = S \times p \times t \times l \qquad (2)$$

where

- r = Distance center of gravity of adjustable weight from point of frame suspension;
- R = Distance center of gravity of saw frame to point of suspension;
- w = Weight of adjustable weight;
- W = Weight of saw frame, etc.;
- T = Total pressure on saw;
- K = Distance center of bar cut to point of frame suspension;
- S = Standard pressure per inch of tooth width;
- p = Pitch of saw;
- t = Thickness of blade;
- l = Length of saw cut = diameter of bar cut

To illustrate, assume conditions as following:

r = to be determined;	K = 18 in.;
R = 20 lb.	S = 30 lb.;
w = 15 lb.	p = 12;
W = 30 lb.	t = 0.048 in.;
T = to be calculated;	l = 3 in.

T = 51.8 lb. from (2)
r = 22 in. from (1)

In Fig. 2 is shown a hacksaw machine that illustrates the approximate lines of action of the forces mentioned above.

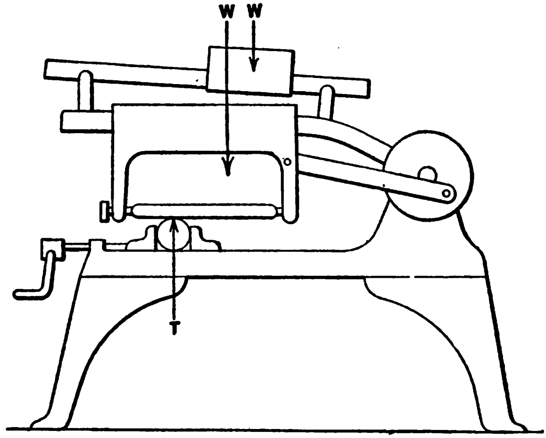


FIG. 2

The figures given for feeding pressure on saws are, of course, general, and to secure the best results tests should be made not only of the different blades but, after the most desirable has been selected, the most efficient feed should be determined for the different materials on which it will be used."—*F. E. Merriam in American Machinist of April* 5*th,* 1917.

THE TESTING OF A HACK SAW BLADE

By J. C. Miller,

Prize Winner of Contest

How can I prove the statements given to me by manufacturers of hack saw blades to be true or otherwise? Does this saw cut fastest and last longest? Is that one cheapest in the long run? Is the output of that other one the maximum at the lowest price per cut?

These are some of the statements and representations of saw salesmen and I wish to put the goods to the test and buy with my eyes wide open, uninfluenced by the sweet songs of the gifted singers whose interests are not always my interests. I will be shown.

I at once look for a system of saw testing that is simple. I wish one that cannot be questioned, one that does not depend upon the likes and dislikes of a workman who may be biased. I insist that all personal elements be cut from my testing system and cold facts only be registered with no human favoritism in the test at any point. I wish for uniformity in the test so that my results may be compared and one saw may be worked against another under exactly similar conditions of speed, length of stroke, pressure upon blade, tension applied to blade and density and hardness of material cut.

I wish to learn the time of cutting and learn when it is best to throw a saw into the scrap because it is a time killer for time is of more importance than the working of a dull saw to the last possible stroke.

A slow cutting saw is a money loser for me even more than I may suspect.

The personal element must be cut out of the test, therefore a power saw machine is required. No dependence can be placed upon hand testing. No comparative results can be attained by hand methods. No two men use a saw alike and the same man saws differently at different times, as his moods and conditions vary. Hands become tired as strokes multiply and saws must be run to the limit. No counting nor timing device can be added to a man's equipment that will record results. A power machine is

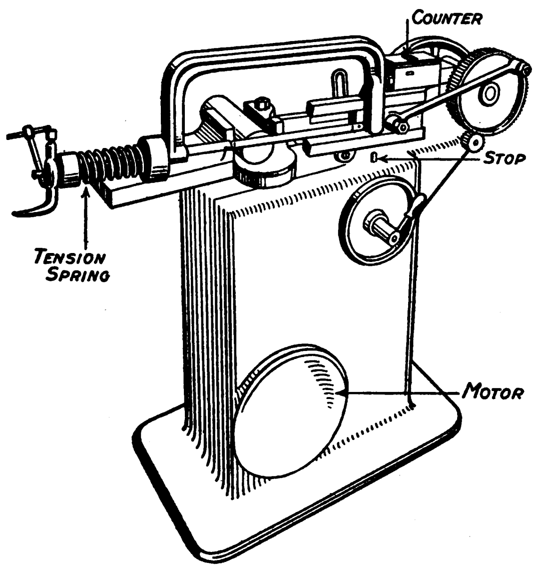


FIG. 3

Sawing Machine on Which the Blade Tests Were Made

therefore necessary and this stock pattern, motor driven saw now in my machine shop will answer every purpose and it need not be changed or disturbed so as to put it out of operation, only for very short intervals at a time. This machine makes sixty strokes per minute, a good speed, and I find that the length of the stroke is six inches. This gives me at once an important item in my record, namely; that thirty feet of saw teeth travel over my work per minute.

I add a counter to this machine as I wish to record the strokes a certain saw makes in doing a piece of work. This I construct of a ratchet driven Veeder counter taken from a punch press and this counter I place inside of an outlet box obtained from the electrician. A rod returned by a spring operates this ratchet and this rod is struck by the saw frame at the beginning of each stroke. A piece of glass is arranged in the cover to allow the figures to be readily seen and to protect the counter itself from dust and molestation. An automatic stop shuts off the saw at the completion of each cut.

In order to have a constant strain on the different saws under test I substitute a new clamp and tightening rod in the frame. On this I place a compression

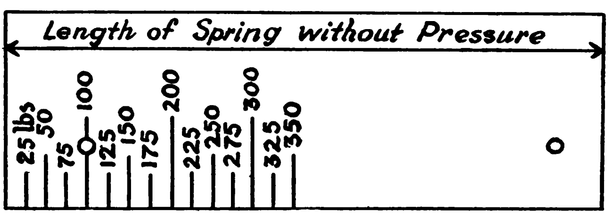


FIG. 4

Gauge Under Tension Spring (reduced from 5⅛ inches)

spring that I have used for other tests and of which I have a record. I know when this spring is of certain length it is exerting a known force and a wing nut brings it quickly to the length I desire.

I see that my saw blades line up perfectly by a lining strip so that there is no twist to the blade and also that the cut is square with the supporting bed. I wish saw blades to run straight for the quality of the set of the teeth is determined thereby. A poor running saw is a tool of no value.

What shall I cut when testing a saw? I wish a steel that is uniform in texture, a constant cross section and a section easily obtained, a size large enough to require little attention, with a medium hardness and density. All these qualities I find in cold rolled shafting of one and fifteen-sixteenths inches diameter. When running tests of one saw against another I will change saws at every cut so that no variation in hardness of material may enter. A slice of this shafting one-eighth of an inch in thickness will answer for a cut so the cost is little for the testing stock.

The pressure on the material being cut by my saw blade, I find by passing a rope, carried by a spring balance, under the teeth of the saw. When I lift the saw from the work the spring balance tells me the pressure that the saw is under at the point where the rope passes. The average of the two ends of the stroke may well be taken as the proper one. This pressure will later be changed to test the pressure of the blade as an element of the life and utility of the blade itself. This pressure I can readily change by the substitution of various weights, carried on the frame.

As a result of the various devices I have assembled

all of which are simple and inexpensive I have in my testing machine the following desirable qualities:

A constant speed,
A constant stroke,
A constant pressure,
A constant tension and
I have selected for sawing
A constant material.

The only variable in my test is the saw blade quality and this I am to determine.

I have eliminated

Man's likes and dislikes,
Man's faulty judgment unguided by cold facts,
Man's tendency toward weariness,
Man's variability,
Man's susceptibility to flattery and cigars.

I have spent only the price of a few dozen saw blades in preparation and the results that I secure I will file where they will be accessible and will serve me in my selection. I can show the salesman while he waits.

A TEST FOR QUALITY

Now that I am provided with this simple equipment I am ready for my first test and it will be for speed in cutting, for time is most important when it must be paid for so dearly in money. As a start toward the selection of the best saw blade I will go into the open market and from the shelves of the dealers I will buy and pay for a few of the best known makes. In order that I may still have uniformity in all things I will use one half inch wide, fourteen tooth, twenty-three gauge, all hard hand blades. This is the regular tooth and a much used blade. I will take

one from each bundle, at random and I will grind a notch in its back to identify it and forget the maker for I do not wish to be influenced by any name. I will run this test with five different makes, so my blades are notched from one to five and all records will be kept under this numbering system.

I am ready for the first cut and I start as follows: No. 1 saw blade is placed properly in the frame. One hundred and fifty pounds tension is placed upon it (I have never lost a saw by overstrain and have failed with many because of understrain) as determined by rule and scale of pressures before referred to. The blade is tested by a lining gauge to see that there is no twist in it from end to end and that it runs true. The stroke counter is read and recorded. The pressure is tested and the saw blade is lowered carefully to the cold rolled stock.

It is planned to make the first stroke always a draw stroke for the sake of uniformity and the wishes of some manufacturers. Power is turned on and the apparatus is left to itself without further attention, only occasional glances being given to its operation as I pass it in the regular order of business. When the cut is completed the saw stops automatically, and saw blade No. 2 is substituted for No. 1 blade; the strokes are recorded that No. 1 required for the test cut and the stock for cutting is moved along an eighth of an inch and the sawing process proceeds again.

The saw blade is changed at every cut to allow for any variation in test stock hardness. When saw blade No. 3 is reached after a fair start, the cut becomes crooked and the saw runs badly to one side. An examination shows that the teeth are unevenly set, being driven more to one side than the other. The saw breaks because of this when the cut is two-thirds com-

pleted. A new saw blade is substituted for this one of the same kind and it runs likewise in a curve from the same cause and breaks. A third saw from the same bundle makes good and finishes a complete cut, running true. Here then is the first thing I must look for in a hack saw blade—

See that the teeth are evenly set to secure true cutting quality.

When the five saw blades have made one cut each I make a table of results and convert these results, so as to appear as dollars and cents, for that appeals strongly to me. The basis of this calculation is the labor cost of a machinist's time figured at 45 cents per hour with a cutting rate of sixty strokes per minute. My results show as follows:

Saw Number	First cuts of five different blades. Number of strokes needed to cut 1 15/16" cold rolled steel, round.	Time cost in cents at 45c for 3600 strokes or 80 strokes for 1c.	
1	808	$0.101	
2	1070	.133	
3	1059	.132	see note.
4	1252	.156	
5	1013	.129	

Note: Two saw blades of No. 3 type ran crooked and were failures.

It will be seen that there is a wide difference in appearance in saw blades 1 and 4. Does this appearance indicate anything? This is a point for future study. I take a look at the teeth of blades 1 and 4 with my pocket glass and I can see why one cuts with two-thirds the strokes of the other. The setting of blade 1 is peculiar. Does this peculiarity explain the superiority? Blade 1 has very sharp clean teeth with a good hook. This is evidently something to be looked for.

This first series of cuts then has given me much to indicate the vital points in saw superiority and has provided me with many leads to follow in hack saw blade selection. I will now make a second cut with the same set of blades as before in the same way and I get these results that appeal to me strongly.

Cuts One and Two shown together

Saw Number	1st cut strokes	1st cut Cost	2nd cut strokes	2nd cut Cost	Increase in time, cost, cts.
1	808	.101	1188	.146	.035
2	1070	.133	2322	.291	.158
3	1059	.132	5307	.663	.531
4	1252	.156	3338	Half off, did not finish	
5	1013	.129	2921	.365	.236

I see from the above table that it is a losing venture for me to use any of the above blades for a second cut save blade No. 1, for the increase in labor cost is way beyond the value of a new blade.

This is a fact that has never appealed to me so strongly before and I make a mental note of the appearance of those blades that should be on the scrap pile rather than in a saw frame. They look fair but their cutting value is gone. How many saw users are losing money by the too long use of a dull blade?

No. 4 blade is unable to make two cuts and is out of the race. No. 3 blade is too soft. This shows on the teeth by aid of the magnifier.

A third series of cuts is made and the record of the blades is as follows:

Blade number	Strokes	Cost of the cut	Increase in cost over last cut
1	2535	$0.317	$0.171
2	5977	.749	.458
3	2395 (When the saw ceased cutting. Did not finish.)		
4	(This blade had failed previously.)		
5	5117 (This blade ran crookedly and broke. No cut.)		

I now find that but two blades survive and they are Nos. 1 and 2. It does not pay to use these longer but for the sake of the test of their long cutting ability I will run a fourth cut. No. 1 makes the cut in 3425 strokes at a labor cost of 43 cents while No. 2 never finishes the fourth cut. The point when no particles of steel are visible on a sheet of white paper is held to be the stopping point of cutting.

Saw blade No. 1 then is tried again and I find it makes the fifth cut in 4520 strokes and finishes the cut with the saw still making good headway. No good will come from trying this further as it is much the superior blade having no competitor near it. The test for quality I now bring to a close and find

Saw Blade No. 1 cuts fastest,
Saw Blade No. 1 cuts most for the money,
Saw Blade No. 1 cuts truest and lasts longest.

A TEST FOR UNIFORMITY AMONG SAW BLADES FROM THE SAME PACKAGE

It may be urged that I happened to get hold of a superior blade in the test for quality described above, as I selected a blade at random and luck provided me with a good one. To prove that blades in the same bundle may vary largely I am going to run a second test and this will prove uniformity which is a great advantage or the lack of it which is a corresponding fault.

Three saw blades are taken at random from an original bundle, all being of the same make, size and kind. They are notched 1, 2 and 3 on their backs for identification and records are kept under these numbers.

The details of these tests are as before; the blades are changed every cut in rotation and but two cuts are made by each blade. The result of this test is shown in the table below.

Saw Blade Number	Strokes to finish first cut	Cost of Labor	Strokes to finish second cut	Cost of Labor
1	2437	$0.304	4450	$0.556
2	1333	.169	1640	.205
3	1584	.198	1993	.249

The results show that from the same box and package, blades may be found having double the value of the others. One of the above blades had but half the value to me of the other under precisely similar conditions and the statement that all saws in the same box are the same may be proven to be false or true as the fact is.

In the light of this last test, such tests as those for quality on which the result is dependent upon a single blade, are not as true a test as where the average of several blades is taken as the real value for a given brand of blade. This latter test will consume more time but will give more accurate results and will be worth while. The test will be conducted exactly as the test first described but the value used will be an average one, hence a truer one.

A TEST FOR THE BEST PRESSURE FROM THE STANDPOINT OF ECONOMY OF TIME AND SAW BLADES

How hard shall we bear down on a hand blade in order to do best is another question that is a matter of debate. We can readily test this and prove that

a certain procedure gives the most cuts for the money. This is the measure of a saw blade's utility.

I ran such a test as follows: From a bundle of blades of a given kind, alike as far as the eye can see, I selected several and these I ran under a light pressure of five and a half pounds. From the results of the strokes needed to make the cut by the several blades, I selected two that seemed to be alike, in cutting ability. These I then ran against each other, assuming that they were equally good.

The result of this selected pair in its first cut was as below:

Pressure 5½ pounds
Saw blades ½" wide, 14 teeth, 10" long

Strokes for No. 1	Cost of cut	Strokes for No. 2	Cost of cut
3025	$0.374	3120	$0.39

This pressure is much too light for economy as other tests have shown, but it is for selection only. The pressure on No. 2 blade was then increased to 21 pounds, while that on No. 1 was increased to 14 pounds. The record was the following:

Strokes for No. 1	Cost of cut	Strokes for No. 2	Cost of cut
1849	$0.231	908	$0.113
	THIRD CUT		
5741	.717	1323	.165
	FOURTH CUT		
8732	and could not finish	1748	.214
	FIFTH CUT		
Pressure increased on No. 1 and unchanged on No. 2, 21 pounds on No. 1			
5337	(for 5/6ths of a cut. Failed.)	1762	.220

SIXTH CUT

No. 2 unchanged. 27 pounds on No. 1.

5841 **for 3/4th cut. Failed.** 2230 .278

SEVENTH CUT

2672 .334

with No. 2 still cutting at the close.

These results showed plainly that it pays to put heavy pressure on saw blades early in their use. It will be seen that No. 2 blade under a light load made more strokes for three cuts than its competitor did for seven cuts under heavier pressure. The glass

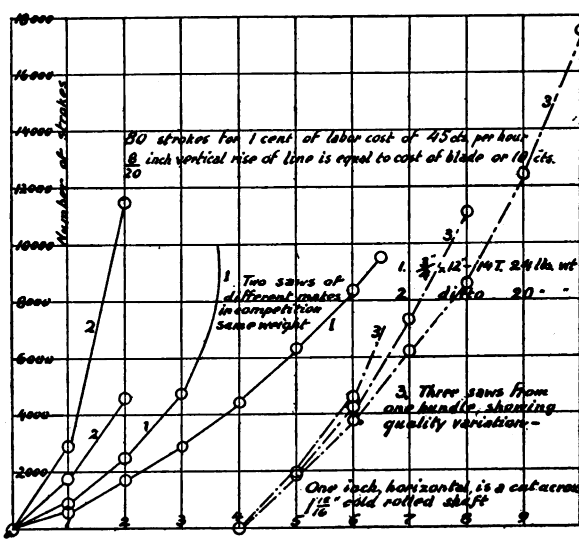


FIG. 5

Graph of Saw Blade Tests Illustrating Effect of Pressure and Quality and Lack of Uniformity on Output

also showed that the width of the teeth tops on both blades was nearly proportional to the number of strokes and not to the pressure. Flat tooth tops devoid of clearance result therefore rather from wear than from use. Flat tooth tops decrease cutting ability and must be absent if the blade is to cut.

Spare the mechanic's time and increase the cuts for the money by using heavy pressures over light ones. Wear out the saw from legitimate cutting use and not from sliding over the work. Wear out the blade and spare the man and the pocket book.

HARDNESS TESTING DEVICES AND HACK SAW BLADE PERFORMANCE

The question naturally arises:—Is it possible to tell a good blade in advance of its use? In order to answer this correctly, five different blades, whose cutting ability had been carefully ascertained by cutting tests, carried to the limit, were subjected to two well known and extensively used instruments for the determination of hardness. They were the scleroscope and the Brinel ball test. The results are given in points of hardness. Readings, ten in number, were taken on each of the five blades and the average of the ten was taken as correct for that blade. These readings were taken on a spot carefully ground by a wet grindstone, in order that the steel might not be changed, and the readings were taken by an expert with the instruments. The conclusion is—

That you cannot tell a good saw or pick out a good cutting blade by means of these instruments. The best cutting saw gave the lowest readings in the hardness scale. This experiment confirms a previous one made along the same lines.

FLEXIBLE HACK SAW BLADES

A question arises in my mind as in that of every hack saw user as to the economy of using flexible blades. With my seasoned mechanics, is there any saving? True there would be with a shop full of amateur workers, but how is it for me? To settle this point for myself I conduct the tests outlined below and find the following results.

I conduct my test with a ten-inch flexible blade having 18 teeth per inch. At first the lack of stiffness causes me to increase my tension and 190 pounds is used. This may seem impossible but blades stand it without shearing a pin or tearing an end hole and a firm rigid saw is the result. Without this blades wobble about and do poor work.

This fact appears at once—*That increased tension must be used on flexible blades* over all hard ones to overcome the lack of rigidty in the former.

The blades are first tried on cold rolled steel and the results are very poor. After 4689 strokes on a 1 15/16 inch cold rolled shaft the saw stopped cutting, under 21 pounds pressure. The saw could not sustain greater pressure but would buckle under it. With this number of strokes it cut the shaft half off only. An all hard blade made the complete cut in 2049 strokes under the same pressure and was still cutting rapidly at the close of the cut.

This test showed me that *it is not the place to work a flexible blade.*

This same blade that had ceased cutting was now worked on one-half-inch electrical pipe conduit and it made ten cuts across this conduit without losing a tooth, averaging 72 strokes per cut under 21 pounds

pressure and it promised to cut on forever. Here was a fine place for such a blade and a hard blade tried in its place lost some of its teeth on the second cut and failed completely after seven cuts. Therefore *use flexible blades for conduit,* with a heavily strained saw frame, the saw blade to have finer teeth than regular.

The same blade as above was then transferred to thin brass tubing, one inch in diameter and of twenty-two gauge. This is a difficult job for any blade but the flexible one performed splendidly. With a reduced pressure of twelve pounds, a tension of 190 pounds and sixty strokes per minute, the flexible blade made cut after cut without losing teeth and showing no signs of failure. Sixty strokes per cut were required. A new all hard blade with 14 teeth failed to make the sixth cut across but broke after having its teeth torn out.

Here then is the proper place for the flexible, fine toothed blade and not for the all hard blade.

SUMMARY

Mechanical devices, devoid of personal elements, are alone adapted to hack saw testing.

But one variable can be determined at once. All other items save the one under test must be capable of measurement and repetition.

Blades for testing should be obtained from store stock and not from selected samples submitted.

The setting of the teeth should be inspected before any time is devoted to a running test. Uneven or one-sided setting gives uneven cutting and crooked work, causing broken blades.

Broken all hard blades occur from misuse or abuse. A properly set blade rarely breaks from use or over-strain.

External appearances indicate little of the worth of a blade. A well scaled blade indicates sufficient heat in the hardening process but tells nothing of the after treatment.

More blades fail from softness than from hardness too extreme or from burning. Soft blades fail soonest.

Blades in cutting operations *are damaged more* by too little pressure than by too much. Also by too little rather than by too much tension. The return stroke, unraised from the work, is as great a cause of loss of cutting ability as dullness due to useful work.

The ideal pressure on a saw blade is a progressive one, increasing from little at the start to the maximum at the close, gradually.

Tooth clearance in a saw blade is lost during the first few cutting strokes and after that the blade cuts because it is forced into the work. A balance is soon reached between the area of the tooth top, the resistance of the material to be cut and the pressure on the blade. Then cutting ceases. Increased pressure renews cutting. Hard material needs greater pressure than soft.

Hardness testing devices give no clew to the best blades. Thinness of the material of the blade seems to render indications valueless.

The most vital points in saw blade operation are

A high tension giving a rigid blade.
A graduated pressure from start to finish.
A relieved pressure on the backward stroke.

HOW STAR BLADES ARE MADE

INCLUDE Star Hack Saws in your tests and make sure you have an accurate comparison of the relative cost per cut and Star Blades will show the greatest efficiency in almost every case.

And there are the best of reasons why they should.

The better cutting qualities of Star Blades start with the special steel of which they are made. For the first ten years that we made Star Blades we bought steel of standard quality in the open market. But for the last twenty-five years we have used steel of our own special formula which has been the result of constant research and investigation. This formula has been modified from time to time to take advantage of every new discovery in steel making which would help make Star Saws faster cutting and tougher to withstand strains.

Steel Formula

The Star steel formula today includes Tungsten in just the right percentage to give the maximum high speed qualities without sacrificing the essential strength and endurance for which Star Blades are famous.

Our special heat treatment and tempering—

Tempering

Gauging blade width,
thickness and set

that last step in making Star Saws which determines the final quality of the steel—was developed entirely by us and differs from the ordinary practice in many important essentials.

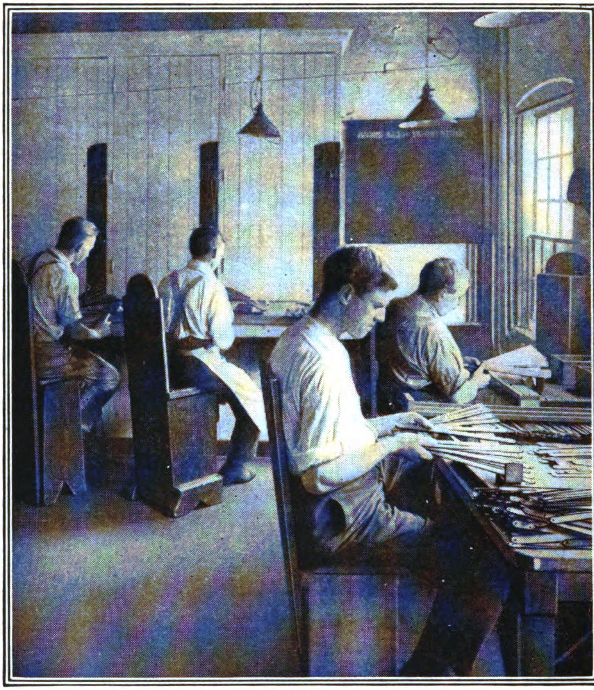
Special Furnace

Our furnace was a twenty-year evolution. We developed more than that number of furnaces in successive years and abandoned each in turn when we discovered a better type to take its place. Our present type of furnace has remained unchanged for the past ten years because it is so efficient it has never been possible to improve it in any essential particular.

Perhaps the most radical difference in our tempering comes in the quenching and after-quenching treatment which is a secret process that adds greatly to the cutting speed and endurance of the blades. With our special pyrometers, we carry heat regulation to a minuteness of accuracy never before attempted—an accuracy which is one of the many causes of Star uniformity.

Cutting Blanks

Through every process of manufacturing Star Blades, we have carried this minute accuracy to the highest point which is mechanically possible. It is a Star policy of fundamental importance which prevails from one end of our plant to the other. This accuracy starts with the blanks which are cut to uniform size within the most exact gauge limits. The sizes are the same year



*Final blade
Inspection*

after year so that even the products of different years are absolutely identical in size.

From the cutter, the blades go to the "toother" which in an important sense is the most vital operation of all. No saw can be better than the cutting ability of its teeth. They must be so shaped and set as to cut fast and yet have the wearing qualities which will give them strength and endurance.

During the entire thirty-five years that we have been making saws this problem of designing tooth shape and set to meet varying conditions and materials has received the constant studying and investigation which its importance deserves. In that time hundreds of thousands of tests have given us working data of priceless importance.

Special "Toother"

Years ago we discovered that the ordinary milling process with a single cutter such as all other hack saw makers use, is so limited in the shape of tooth it can cut, that it can never give the saw teeth maximum cutting speed and endurance. So we developed a special toothing machine which cuts the teeth by a series of cutters which control the shape of these teeth absolutely—a thing that is quite impossible with ordinary milling. With this special machine we can make saw teeth of any desired shape with great rapidity.

Beyond question this machine and the knowledge of tooth cutting behind it, are the two greatest single reasons for Star Blade superiority. They make Star Saws the fastest cutting, longest wearing blades on the market and keep a wide margin of cutting superiority between the Star and the next best blades.

Automatics

After the blanks are toothed, they go to an automatic machine which does 14 separate operations formerly done by hand. These machines are adjusted with such minute accuracy that they stop if a single blade shows the slightest variation in the operations these machines perform. They have replaced whole rows of hand operatives and a number of foremen in our factory. The machines do the work infinitely better and far cheaper than hand operatives under the closest superintendence.

Inspection

The final guarantee of Star quality comes from the inspection which is an effective check on all that has gone before. Our automatic machinery effects such radical savings that we can afford to make our inspection a minute scrutiny of every blade that goes out.

These blades must be free from all imperfections, must give proof of proper temper and must check up to the most accurate gauge limits in thickness and set.

Every inspector is a picked man who has had

at least 15 years experience covering every department of our factory. In every case he is a man whom we know we can trust to see that every blade which leaves our factory comes up to the Star quality standard.

Why the Star Is Better

These are some of the solid tangible reasons why Star Blades will give you the same efficient results day in and day out, year in and year out, that they show in your comparative tests. Make the tests at first by all means to satisfy yourself. Then look for the Star trademark on the subsequent hack saws you buy—the brand that will enable you to continue the same efficiency in your hack saw department as long as the Star mark is stamped on blades.